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PROBLEMS OF PHYSICS[1]

MY predecessor in office a year ago reminded you that the theoretical researches of Einstein and Weyl suggest that not merely the material universe but space itself is perhaps finite. As to the probabilities I do not wish to express an opinion; but the statement is significant of the extent of the revolution in the conceptions and fundamental principles of physics now in progress. That space need not be infinite has, I believe, long been recognized by geometricians, and appropriate geometries to meet its possible limitations have been devised by ingenious mathematicians. I doubt, however, whether these inventive gentlemen ever dreamed that their schemes held any objective validity such as would assist the astronomer and the physicist in understanding and classifying material phenomena. It is not certain that they will; but the possibility is definite. Apart from this, the whole development of relativity is an extraordinary triumph for pure mathematics. Had Einstein not found his entire calculus ready to hand, owing to the purely mathematical work of Christoffel, Riemann, and others, it seems certain that the development of generalized relativity would have been much slower. It is a pleasure to be able to acknowledge this indebtedness of physics and astronomy to pure mathematics.

Relativity is the revolutionary movement in physics which has caught the public eye, perhaps because it deals with familiar conceptions in a manner which for the most part is found pleasantly incomprehensible. But it is only one of a number of revolutionary changes of comparable magnitude. Among these we have to place the advent of the quan-

[1] Address of the President of Section A—Mathematics and Physics, British Association for the Advancement of Science, Edinburgh, September, 1921.

tum, the significance of which I hope we shall thoroughly discuss early next week. The various consequences of the electronic structure of matter are still unfolding themselves to us, and are increasing our insight into the most varied phenomena at a rate which must have appeared incredible only a few decades ago.

The enormous and far-reaching importance of the discoveries being made at Cambridge by Sir Ernest Rutherford can not be overemphasized. These epoch-making discoveries relate to the structure and properties of the nuclei of atoms. At the present time we have, I think, to accept it as a fact that the atoms consist of a positively charged nucleus of minute size, surrounded at a fairly respectful distance by the number of electrons requisite to maintain the structure electrically neutral. The nucleus contains all but about one two-thousandth part of the mass of the atom, and its electric charge is numerically equal to that of the negative electron multiplied by what is called the atomic number of the atom, the atomic number being the number which is obtained when the chemical elements are enumerated in the order of the atomic weights; thus, hydrogen = 1, helium = 2, lithium = 3, and so on. Consequently the number of external electrons in the atom is also equal to the atomic number. The evidence, derived from many distinct and dissimilar lines of inquiry, which makes it necessary to accept the foregoing statements as facts, will be familiar to members of this Section of the British Association, which has continually been in the forefront of contemporary advances in physical science. But I would remind you in passing that one of the important pieces of evidence was supplied by Professor Barkla's researches on the scattering of X-rays by light atoms.

The diameters of the nuclei of the atoms are comparable with one millionth of one millionth part of a centimeter, and the problem of finding what lies within the interior of such a structure seems at first sight almost hopeless. It is to this problem that Rutherford has addressed himself by the direct method of bombarding the nuclei of the different atoms with the equally minute high-velocity helium nuclei (alpha-particles) given off by radioactive substances, and examining the tracks of any other particles which may be generated as a result of the impact. A careful and critical examination of the results shows that hydrogen nuclei are thus expelled from the nuclei of a number of atoms such as nitrogen and phosphorus. On the other hand, oxygen and carbon do not eject hydrogen under these circumstances, although there is evidence in the case of oxygen and nitrogen of the expulsion of other sub-nuclei whose precise structure is a matter for further inquiry.

The artificial transmutation of the chemical elements is thus an established fact. The natural transmutation has, of course, been familiar for some years to students of radioactivity. The philosopher's stone, one of the alleged chimeras of the mediæval alchemists, is thus within our reach. But this is only part of the story. It appears that in some cases the kinetic energy of the ejected fragments is greater than that of the bombarding particles. This means that these bombardments are able to release the energy which is stored in the nuclei of atoms. Now, we know from the amount of heat liberated in radioactive disintegration that the amount of energy stored in the nuclei is of a higher order of magnitude altogether, some millions of times greater, in fact, than that generated by any chemical reaction such as the combustion of coal. In this comparison, of course, it is the amount of energy per unit mass of reacting or disintegrating matter which is under consideration. The amounts of energy which have thus far been released by artificial disintegration of the nuclei are in themselves small, but they are enormous in comparison with the minute amounts of matter affected. If these effects can be sufficiently intensified there appear to be two possibilities. Either they will prove uncontrollable, which would presumably spell the end of all things,[2] or they

[2] To reassure the nervous I would, however, interpolate the comforting thought that this planet has held considerable quantities of radioactive

will not. If they can be both intensified and controlled then we shall have at our disposal an almost illimitable supply of power which will entirely transcend anything hitherto known. It is too early yet to say whether the necessary conditions are capable of being realized in practise, but I see no elements in the problem which would justify us in denying the possibility of this. It may be that we are at the beginning of a new age, which will be referred to as the age of subatomic power. We can not say; time alone will tell.

THERMIONIC EMISSION

With your permission, I will now descend a little way from the summit of Mount Olympus, and devote the rest of my address to a sober review of the present state of some of the questions with which my own thoughts have been more particularly occupied. At the Manchester meeting of the Association in 1915 I had the privilege of opening a discussion on thermionic emission—that is to say, the emission of electrons and ions by incandescent bodies. I recall that the opinion was expressed by some of the speakers that these phenomena had a chemical origin. That view, I venture to think, is one which would find very few supporters now. It is not that any new body of fact has arisen in the meantime. The important facts were all established before that time, but they were insufficiently appreciated, and their decisiveness was inadequately realized.

It may be worth while to revert for a moment to the issues in the controversy, already moribund in 1915, because it has been closely paralleled by similar controversies relating to two other groups of phenomena—namely, photoelectric emission and contact electromotive force—which, as we shall see, are intimately connected with thermionic emission. The issue was not as to whether thermionic emission may be looked upon simply as a type of chemical reaction. Such an issue would have been largely a matter of nomenclature.

matter for a very long time without anything very serious happening so far as we know.

Thermionic electron emission has many features in common with a typical reversible chemical reaction such as the dissociation of calcium carbonate into lime and carbon dioxide There is a good deal to be said for the point of view which regards thermionic emission as an example of the simplest kind of reversible chemical action, namely, that kind which consists in the dissociation of a neutral atom into a positive residue and a negative electron, inasmuch as we know that the negative electron is one of the really fundamental elements out of which matter is built up. The issue in debate was, however, of a different character. It was suggested that the phenomenon was not primarily an emission of electrons from the metallic or other source, but was a secondary phenomenon, a kind of by-product of an action which was primarily a chemical reaction between the source of electrons and some other material substance such as the highly attenuated gaseous atmosphere which surrounded it. This suggestion carried with it either implicitly or explicitly the view that the source of power behind the emission was not the thermal energy of the source, but was the chemical energy of the postulated reaction.

This type of view has never had any success in elucidating the phenomena, and I do not feel it necessary at this date to weary you with a recital of the facts which run entirely counter to it, and, in fact, definitely exclude it as a possibility. They have been set forth at length elsewhere on more than one occasion. I shall take it to be established that the phenomenon is physical in its origin and reversible in its operation.

Establishing the primary character of the phenomenon does not, however, determine its nature or its immediate cause. Originally I regarded it as simply kinetic, a manifestation of the fact that as the temperature rose the kinetic energy of some of the electrons would begin to exceed the work of the forces by which they are attracted to the parent substance. With this statement there is, I think, no room for anyone to quarrel, but it is permissible to inquire how the escaping electrons

obtain the necessary energy. One answer is that the electrons have it already in the interior of the substance by virtue of their energy of thermal agitation. But thermal agitations now appear less simple than they used to be regarded, and in any event they do not exhaust the possibilities.

We know that when light of short enough wave-lengths falls on matter it causes the ejection of electrons from it—the so-called photoelectric effect. Since the formula for the radiation emitted by a body at any given temperature contains every wave-length without limitation, there must be some emission of electrons from an incandescent body as the result of the photoelectric effect of its own luminosity. Two questions obviously put themselves. Will this photoelectric emission caused by the whole spectrum of the hot body vary as the temperature of the incandescent body is raised in the way which is known to characterize thermionic emission? A straightforward thermodynamic calculation shows that this is to be expected from the theoretical standpoint, and the anticipation has been confirmed by the experiments of Professor W. Wilson. Thus the autophotoelectric emission has the correct behavior to account for the thermionic emission. The other question is: Is it large enough? This is a question of fact. I have considered the data very carefully. There is a little uncertainty in some of the items, but when every allowance is made there seems no escape from the conclusion that the photoelectric effect of the whole spectrum is far too small to account for thermionic emission.

This question is an important one, apart from the particular case of thermionic emission. The same dilemma is met with when we seek for the actual *modus operandi* of evaporation, chemical action, and a number of other phenomena. These, so far as we know, might be fundamentally either kinetic or photochemical or a mixture of both. In my judgment the last alternative is the most probable. (I am using the term photochemical here in the wide sense of an effect of light in changing the composition of matter, whether the parts affected are atoms, groups of atoms, ions, or electrons.) For example, the approximation about boiling points known as Trouton's rule is a fairly obvious deduction from the photochemical standpoint. The photochemical point of view has recently been put very strongly by Perrin, who would make it the entire *motif* of all chemical reaction, as well as of radioactivity and changes of state. In view of the rather minor part it seems to play in thermionic emission, where one would *a priori* have expected light to be especially effective, this is probably claiming too much for it, but the chemical evidence contains one item which is certainly difficult to comprehend from the kinetic standpoint. The speed of chemical decomposition of certain gases is independent of their volume, showing that the decomposition is not due to molecular collisions. The speed does, however, increase very rapidly with rising temperature. What the increased temperature can do except increase the number and intensity of the collisions, factors which the independence of volume at constant temperature shows to be without effect, and increase the amount of radiation received by the molecules, is not too obvious. It seems, however, that, according to calculations by Langmuir,[3] the radiation theory does not get us out of this difficulty; for, just as in the ordinary photoelectric case, there is nothing like enough radiation to account for the observed effects. It seems that in the case of these mono-molecular reactions the phenomena can not be accounted for either by simple collisions, or by radiation, or by a mixture of both, and it is necessary to fall back on the internal structure of the decomposing molecule. This is complex enough to afford material sufficient to cover the possibilities; but, from the standpoint of the temperature energy relations of its parts, it can not at present be regarded as much more than a field for speculation.

CONTACT ELECTRICITY

A controversy about the nature of the contact potential difference between two metals,

[3] *Journ. Am. Chem. Soc.*, Vol. XLII., p. 2190 (1920).

similar to that to which I have referred in connection with thermionic emission, has existed for over a century. In 1792 Volta wrote: "The metals . . . can by themselves, and of their own proper virtue, excite and dislodge the electric fluid from its state of rest." The contrary position that the electrical manifestations are inseparably connected with chemical action was developed a few years later by Fabroni. Since that time electrical investigators have been fairly evenly divided between these two opposing camps. Among the supporters of the intrinsic or contact view of the type of Volta we may recall Davy, Helmholtz, and Kelvin. On the other side we have to place Maxwell, Lodge, and Ostwald. In 1862 we find Lord Kelvin [4] writing:

> For nearly two years I have felt quite sure that the proper explanation of voltaic action in the common voltaic arrangement is very near Volta's, which fell into discredit because Volta or his followers neglected the principle of the conservation of force.

On the other hand, in 1896 we find Ostwald [5] referring to Volta's views as the origin of the most far-reaching error in electrochemistry, which the greatest part of the scientific work in that domain has been occupied in fighting almost ever since. These are cited merely as representative specimens of the opinions of the protagonists.

Now, there is a close connection between thermionic emission and contact potential difference, and I believe that a study of thermionic emission is going to settle this little dispute. In fact, I rather think it has already settled it, but before going into that matter I would like to explain how it is that there is a connection between thermionic emission and contact potential difference, and what the nature of that connection is.

Imagine a vacuous enclosure, either impervious to heat or maintained at a constant temperature. Let the enclosure contain two different electron-emitting bodies, A and B. Let one of these, say A, have the power of emitting electrons faster than the other, B. Since they are each receiving as well as emitting electrons, A will acquire a positive and B a negative charge under these circumstances. Owing to these opposite charges A and B will now attract each other, and useful work can be obtained by letting them come in contact. After the charges on A and B have been discharged by bringing them in contact, let the bodies be quickly separated and moved to their original positions. This need involve no expenditure of work, as the charges arising from the electron emission will not have had time to develop. After the charges have had time to develop the bodies can again be permitted to move together under their mutual attraction, and so the cycle can be continued an indefinite number of times. In this way we have succeeded in imagining a device which will convert all the heat energy from a source at a uniform temperature into useful work.

Now, the existence of such a device would contravene the second law of thermodynamics. We are therefore compelled either to deny the principles of thermodynamics or to admit that there is some fallacy as to the pretended facts in the foregoing argument. We do not need to hesitate between these alternatives, and we need only look to see how the alleged behavior of A and B will need to be modified in order that no useful work may appear. There are two alternatives. Either A and B necessarily emit equal numbers (which may include the particular value zero) of electrons at all temperatures, or the charges which develop owing to the unequal rate of emission are not discharged, even to the slightest degree, when the two bodies are placed in contact.

The first alternative is definitely excluded by the experimental evidence, so I shall proceed to interpret the second. It means that bodies have natural states of electrification whereby they become charged to definite potential differences whose magnitudes are independent of their relative positions. There is an intrinsic potential difference between A and B which is the same, at a given temperature, whether they are at a distance apart or in con-

[4] Papers on Electrostatics and Magnetism, p. 318.

[5] "Elektrochemie, Ihre Geschichte und Lehre," p. 65, Leipzig (1896).

tact. In the words of Volta, which I have already quoted, "the metals can by themselves, and of their own proper virtue, excite and dislodge the electric fluid from its state of rest."

Admitting that the intrinsic potentials exist, a straightforward calculation shows that they are intimately connected with the magnitudes of the thermionic emission at a given temperature. The relation is, in fact, governed by the following equation: If A and B denote the saturation thermionic currents per unit area of the bodies A and B respectively, and V is the contact potential difference between them at the absolute temperature T, then $V = kT/e \log A/B$ where k is the gas constant calculated for a single molecule (Boltzmann's constant), and e is the electronic charge.

I have recently, with the help of Mr. F. S. Robertson, obtained a good deal of new information on this question from the experimental side. We have made measurements of the contact potential difference between heated filaments and a surrounding metallic cylinder, both under the high-vacuum and gas-free conditions which are now attainable in such apparatus, and also when small known pressures of pure hydrogen are present. As is well known, both contact potentials and thermionic emission are very susceptible to minute traces of gas, but we find that under the best conditions as to freedom from gas there is a contact potential of the order of one volt between a pure tungsten filament and a thoriated filament. We have also been able to measure the thermionic emissions from the filaments at the same time, and we find that the contact potential calculated from them with the help of the foregoing equation is within 20 per cent. of the measured value. Considering the experimental difficulties, this is a very substantial agreement. Whilst the evidence is not yet as complete as I hope to make it, it goes a long way towards disproving the chemical view of the origin of contact potential difference.

From what has been said you will realize that the connection between contact potentials and thermionic emissions is a very close one. I would, however, like to spend a moment in developing it from another angle. To account for the facts of thermionic emission it is necessary to assume that the potential energy of an electron in the space just outside the emitter is greater than that inside by a definite amount, which we may call w. The existence of this w, which measures the work done when an electron escapes from the emitter, is required by the electron-atomic structure of matter and of electricity. Its value can be deduced from the temperature variation of thermionic emission, and, more directly, from the latent heats absorbed or generated when electrons flow out of or into matter. These three methods give values of w which, allowing for the somewhat considerable experimental difficulties, are in fair agreement for any particular emitter. The data also show that in general different substances have different values of w. This being so, it is clear that when uncharged bodies are placed in contact the potential energies of the electrons in one will in general be different from those of the electrons in the other. If, as in the case of the metals, the electrons are able to move freely they will so move until an electric field is set up which equilibrates this difference of potential energy. There will thus be an intrinsic or contact difference of potential between metals which is equivalent to the difference in the values of w and is equal to the difference in w divided by the electronic charge.[6]

PHOTOELECTRIC ACTION

We have seen that there is a connection on broad lines between thermionic emission and both contact potentials on the one hand and photoelectric emission on the other. The three groups of phenomena are also related in detail and to an extent which up to the present has not been completely explored. In order to understand the present position, let us re-

[6] This statement is only approximately true. In order to condense the argument certain small effects connected with the Peltier effect at the junction between the metals have been left out of consideration.

view briefly some of the laws of photoelectric action as they have revealed themselves by experiments on the electrons emitted from metals when illuminated by visible and ultra-violet light.

Perhaps the most striking feature of photoelectric action is the existence of what has been called the threshold frequency. For each metal whose surface is in a definite state there is a definite frequency n_0, which may be said to determine the entire photoelectric behavior of the metal. The basic property of the threshold frequency n_0 is this: When the metal is illuminated by light of frequency less than n_0 no electrons are emitted, no matter how intense the light may be. On the other hand, illumination by the most feeble light of frequency greater than n_0 causes some emission. The frequency n_0 signalizes a sharp and absolute discontinuity in the phenomena.

Now let us inquire as to the kinetic energy of the electrons which are emitted by a metal when illuminated by monochromatic light of frequency, let us say, n. Owing to the fact that the emitted electrons may originate from different depths in the metal, and may undergo collision at irregular intervals, it is only the maximum kinetic energy of those which escape which we should expect to exhibit simple properties. As a matter of fact, it is found that the maximum kinetic energy is equal to the difference between the actual frequency n and the threshold frequency n_0 multiplied by Planck's constant h. In mathematical symbols, if v is the velocity of the fastest emitted electron, m its mass, e its charge, and V the opposing potential required to bring it to rest,

$$eV = \tfrac{1}{2}mv^2 = h(n - n_0).$$

From this equation we see that the threshold frequency has another property. It is evidently that frequency for which kinetic energy and stopping potential fall to zero. This suggests strongly, I think, that the reason the electron emission ceases at n_0 is that the electrons are not able to get enough energy from the light to escape from the metal, and not that they are unable to get any energy from the light.

The threshold frequencies have another simple property. If we measure the threshold frequencies for any pair of metals, and at the same time we measure the contact difference of potential K between them, we find that K is equal to the difference between their threshold frequencies multiplied by this same constant h divided by the electronic charge e.

These results, as well as others which I have not time to enumerate, admit of a very simple interpretation if we assume that when illuminated by light of frequency n the electrons individually acquire an amount of energy hn. We have seen that in order to account for thermionic phenomena it is necessary to assume that the electrons have to do a certain amount of work w to get away from the emitter. There is no reason to suppose that photoelectrically emitted electrons can avoid this necessity. Let us suppose that this work is also definite for the photoelectric electrons and let us denote its value by hn_0. Then no electron will be able to escape from the metal until it is able to acquire an amount of energy at least equal to hn_0 from the light—that is to say, under the suppositions made—until n becomes at least as great as n_0. Thus n_0 will be identical with the frequency which we have called the threshold frequency, and the maximum energy of any electron after escaping will be $h\ (n—n_0)$.

The relation between threshold frequencies and contact potential difference raises another issue. We have seen that the contact potential difference between two metals must be very nearly equal to the difference between the amounts of work w for the electrons to get away from the two metals by thermionic action, divided by the electronic charge e. The photoelectric experiments show that the contact electromotive force is also nearly equal to the differences of the threshold frequencies multiplied by h/e. It follows that the photoelectric work hn_0 must be equal to the thermionic work w to the same degree of accuracy. We have to except here a possible constant difference between the two. I do not see, however, how any value other than zero for such a constant could be given a rational interpre-

tation, as it would have to be the same for all substances and frequencies. The photoelectric and thermionic works are known to agree to within about one volt. To decide how far they are identical needs better experimental evidence than we have at present. The indirect evidence for their substantial identity (that is to say, within the limits of accuracy referred to above) is stronger at the moment than the direct evidence.

I do not think that the complete identity of the thermionic work w and the photoelectric hn_0 is a matter which can be inferred *a priori*. What we should expect depends to a considerable extent on the condition of the electrons in the interior of metals. We can not pretend to any real knowledge of this at present; the various current theories are mere guesswork. Unless the electrons which escape all have the same energy when inside the metal we should expect the thermionic value to be an average taken over those which get out. The photoelectric value, on the other hand, should be the minimum pertaining to those internal electrons which have most energy. The apparent sharpness of the threshold frequency is also surprising from some points of view. There seems to be scope for a fuller experimental examination of these questions.

I have spoken of the threshold frequency as though it were a perfectly definite quantity. No doubt it is when the condition of the body is or can be definitely specified, but it is extraordinarily sensitive to minute changes in the conditions of the surface, such as may be caused, for example, by the presence of extremely attenuated films of foreign matter. For this reason we should accept with a certain degree of reserve statements which appear from time to time that photoelectric action is some parasitic phenomenon, inasmuch as it can be made to disappear by improvement of vacuum or other change in the conditions. What has generally happened in these investigations is that something has been done to the illuminated surface which has raised its threshold frequency above that of the shortest wave-length in the light employed in the test. Unless they are accompanied by specific information about the changes which have taken place in the threshold frequency, such statements are of little value at the present stage of development of this subject.

Interesting calculations have been made by Frenkel which bring surface tension into close connection with the thermionic work w. Broadly speaking, there can be little doubt that a connection of this nature exists, but whether the relation is as simple as that given by the calculations is open to doubt. It should be possible to answer this question definitely when we have more information about the disposition of the electrons in atoms such as the continuous progress in X-ray investigation seems to promise.

LIGHT AND X-RAYS

One of the great achievements of experimental physics in recent years has been the demonstration of the essential unity of X-rays and ordinary light. X-rays have been shown to be merely light of particularly high frequency or short wave-length, the distinction between the two being one of degree rather than of kind. The foundations of our knowledge of X-ray phenomena were laid by Barkla, but the discovery and development of the crystal diffraction methods by v. Laue, the Braggs, Moseley, Duane, and de Broglie have established their relations with ordinary light so clearly that he who runs may read their substantial identity. The actual gap in the spectrum of the known radiations between light and X-rays is also rapidly disappearing. The longest stride into the region beyond the ultraviolet was made by Lyman with the vacuum grating spectroscope which he developed. For a short time Professor Bazzoni and I held the record in this direction with our determination of the short wave limit of the helium spectrum, which is in the neighborhood of 450 Ångstrom units. More recently this has been passed by Millikan, who has mapped a number of lines extending to about 200 Ångstrom units —that is to say, more than four octaves above the violet limit of the visible spectrum. I am not sure what is the longest X-ray which has been measured, but I find a record of a Zinc

L-ray by Friman [7] of a wave-length of 12.346 Angstrom units. There is thus at most a matter of about four octaves still to be explored. In approaching this unknown region from the violet end the most characteristic property of the radiations appears to be their intense absorption by practically every kind of matter. This result is not very surprising from the quantum standpoint. The quantum of these radiations is in excess of that which corresponds to the ionizing potential of every known molecule, but it is of the same order of magnitude. Furthermore, it is large enough to reach not only the most superficial, but also a number of the deeper-seated electrons of the atoms. There is evidence, both theoretical and experimental, that the photoelectric absorption of radiation is most intense when its quantum exceeds the minimum quantum necessary to eject the absorbing electron but does not exceed it too much. In the simplest theoretical case the absorption is zero for radiations whose frequencies lie below the minimum quantum, rises to a maximum for a frequency comparable with the minimum, and falls off to zero again at infinite frequency. This case has not been realized in practise, but, broadly judged, the experimental data are in harmony with it. On these general grounds we should expect intense absorption by all kinds of matter for the radiation between the ultra-violet and the X-ray region.

The closeness of the similarity in the properties of X-rays and light is, I think, even yet inadequately realized. It is not merely a similarity along broad lines, but it extends to a remarkable degree of detail. It is perhaps most conspicuous in the domains of photoelectric action and of the inverse phenomenon of the excitation of radiation or spectral lines by electron impacts. Whilst there may still be room for doubt as to the precise interpretation of some of the experimental data, the impression I have formed is that each important advance tends to unify rather than to disintegrate these two important groups of phenomena.

O. W. RICHARDSON

[7] *Phil. Mag.*, Vol. XXXII., p. 494 (1916).

SCIENTIFIC ABSTRACTING [1]

Is it worth while for scientific journals to provide abstracts at the beginning of their articles?

The answer to this question depends, of course, on the nature of the abstracts. If they are sketchy, incomplete and unreliable, as many abstracts published at present are, they may be worse than useless. But suppose each abstract describes the contents of the article so completely and precisely that any reader can tell with assurance whether the article contains any results of interest to him, and suppose it summarizes the methods, conclusions and theories so as to give all the information any reader not a specialist in the narrow field involved needs; that is, suppose each is the result of a careful analysis of the article by a competent abstractor, would not such abstracts enable the reader to grasp the significant results in the articles not only more quickly but more completely and clearly than by skimming through the articles?

Such abstracts would save much time for the scientist not only as a *reader* of current literature but also as an *investigator*. For when he desires information on a certain narrow subject, such abstracts would help him to determine more quickly than otherwise which of the articles referred to in a bibliography or other list contain what he needs; and frequently the abstracts would give him the information directly and make a search through the articles unnecessary. Finally, such abstracts would save his time as an *abstractor* at home and abroad. For abstract journals are recognized to be such useful, almost indispensable guides to scientific literature that most sciences have one or more in each of the great scientific languages. At present, then, most of the articles in the fields of astronomy, physics, chemistry, biology, and medicine are abstracted from three to six times each, while if an abstract suitable for reprinting in an ab-

[1] The method of analytic abstracting described in this paper was developed by the writer during 1919–20 while on the staff of the Research Information Service of the National Research Council.

stract journal were prefixed to each original article, a reabstracting of the article would be unnecessary and much duplication of effort would be avoided. Moreover the practise would enable abstract journals to report current literature with less delay than at present.

But to render this service to scientists, the abstracts must, as stated above, adequately describe and summarize the contents of the articles. The standard must not only be high; it must be uniform, so that the abstracts may be beyond suspicion of incompleteness and inaccuracy.

During 1920 the National Research Council devoted considerable attention to various questions relating to abstracts, such as: how they might be improved in form so as to render more effective service; how the rules might be made more definite and the method of preparation more systematic so as to result in more uniformly good abstracts. As a result of study and experimentation a type of abstract was developed which is believed to be well suited to the needs both of abstract journals and of scientific journals with preliminary abstracts.

Abstracts of this type, which are called *analytic abstracts,* have been appearing in the *Astrophysical Journal* and, less consistently, in the *Physical Review* since January, 1920. Their main characteristics are illustrated in the following samples.

1. *A new method of determining the atomic weight of iodine.* Marcel Guichard; Ann. chim., 6, 279–318 (1916); 7, 5–49 (1917).

ABSTRACT

Atomic weight of iodine.—The pentoxide method used involves the preparation of I_2O_5, the decomposition of this anhydrid, and the collection of the iodine by condensation and of the oxygen by combination with pure copper. The mean of five *determinations* is 126.915. The article gives in voluminous detail the refinements employed to guard against error.

Iodine pentoxide; preparation, purification and decomposition with heat.—The results of a thorough study are presented. As it was found impracticable to prepare it by direct combination of I_2 and O_2, the method adopted was to oxidize I_2 with fuming HNO_3 and subsequently expel free I_2 and HNO_3 by heating to 450°. This was carried out in an evacuated train which is fully described.

Preparation of pure iodine.—Detailed directions are given.

Occlusion of oxygen by glass, porcelain and copper was studied in order to determine the best material for the apparatus.

2. *On K. S. magnet steel.* K. Honda and S. Saito; *Physical Review,* 16, 495–500, December, 1920.

ABSTRACT

K. S. magnet steel (C 0.4–0.8, Co 30–40, W 5–9, Cr 1.5–3 per cent).—This remarkable new alloy steel possesses, when tempered, an extremely high *coercive force,* 226–257 gauss, and a strong *residual magnetism,* varying from 620 to 920 C.G.S. units for different specimens. The *effect of repeated shock* was to reduce these values by only 6 per cent. The *hysteresis curves* for a magnetizing force of ±1300 gauss show for the hardened steel an energy loss of 900,000 ergs per cycle. *Tempering* is best effected by heating to 950° C. and quenching in heavy oil. This treatment applied to annealed specimens increases the Brinell *hardness* number from 444 to 652 and makes the *microstructure* finer grained.

3. *The structure of the helium atom.* Irving Langmuir; *Physical Review,* 17, 339–353, March, 1921.

ABSTRACT

Helium atom models.—(1) *Bohr's model* is unsatisfactory because it gives too great a value for the ionizing potential and is not in accord with some of the optical and magnetic properties of helium. Since the chemical evidence suggests that each electron in an atom has its own orbit, separated from the other orbits but closely interrelated with them, two new models are considered. (2) In the *double circle model* the two electrons are assumed to move in two circular orbits, separate

but parallel. This model, however, is unstable, for the ionizing potential computed by applying the quantum theory, comes out negative. Another objection to this model is that the magnetic moment is not zero. (3) In the *semi-circular model* each electron is assumed to oscillate back and forth along an approximately semi-circular path in accordance with classical mechanics, each being brought to rest at each end of its path by the repulsion of the other. Assuming the maximum angular momentum of each electron equal to $h/2\pi$ the absolute dimensions come out such as to give a total energy 0.9618 times that of the Bohr model, and the computed ionizing potential, 25.62 volts, agrees closely with the experimental value. The magnetic moment is zero.

Application of the quantum theory to coupled electrons.—The success of the semi-circular model of helium *suggests* that in the case of coupled electrons the quantum theory should be applied not to the momentum of the individual electrons according to the relation $\int pdq = h/2\pi$, but rather to the momentum which by being relayed from one electron to another, passes in each direction around the nucleus.

4. *Studies on inbreeding. IV. Effects of inbreeding on the growth and variability in body weight of the albino rat.* Helen D. King; *Jour. Exp. Zool.*, 29, No. 1 (1919).

ABSTRACT

Effects of inbreeding on the growth and variability in body weight of the albino rat.—In continuation of previous work, data are given concerning over 600 rats belonging to the *sixteenth to twenty-fifth generations* of a strain bred brother to sister from the same litter only. Allowing for the effect of certain unfavorable conditions, determined by control rats, the results confirm previous conclusions and show that close inbreeding continued for 25 generations has not produced any deterioration in the stock as regards the growth curve, the body weight, the variability of body weight for various ages, and the relative behavior of the sexes in these respects. Selected rats were used as the parents of each generation. If there is any tendency to deterioration it was counteracted in these experiments by the selection employed.

Effect of nutrition on the growth and variability in body weight of the albino rat.—Rats are particularly sensitive to food conditions. Alfalfa, cottonseed and linseed meal were found to be injurious. A change from a satisfactory diet to one less suitable resulted in a marked increase in variability of body weight both for inbred and stock rats.

Sex ratio in the albino rat.—By selection the inbred strain has been separated into two lines, one with a high, the other with a low, sex ratio; but the *effect of selection* seems to be limited. The two strains are alike in body weight, growth curve and variability of body weight.

It will be noticed that each of the one or more paragraphs of each abstract begins with an italicized *paragraph title.* In some cases words or phrases within a paragraph are also italicized. This is not done for emphasis but to associate them with the paragraph titles which they supplement and complete. Paragraph titles and italicized words and phrases will collectively be called *subtitles.* If the reader will run through the sample abstracts, skipping all but these italicized subtitles, he will get in each case a descriptive index of the information in the article. For example:

ABSTRACT NO. 1

Atomic weight of iodine.
Pentoxide method.
Determinations.
Iodine pentoxide.
Preparation, purification.
Decomposition with heat.
Preparation of pure iodine.
Occlusion of oxygen by glass, porcelain and copper.

ABSTRACT NO. 3

Helium atom models.
(1) *Bohr's model.*
(2) *Double circle model.*
(3) *Semi-circular model.*

Application of the quantum theory to coupled electrons; suggestion.

The subtitles, then, form in each case an *index of the abstract.* By glancing through them a reader can tell with assurance whether the article deals with anything of interest to him. It is well known that one can not rely upon the author's title alone, for many articles contain incidental information or a variety of information which a short title can not fully describe. The first and last articles abstracted above are good instances of this fact. On the other hand, the subtitles of this type of abstract, since they may be as numerous as is necessary, can give in all cases the precise scope of the information contained in the article; in particular they can call attention to incidental results whose presence would not be suspected from the title, such as the data relating to the occlusion of oxygen given in the article on the atomic weight of iodine.

Besides providing a complete index in the form of subtitles, the abstracts are required to describe the new information with sufficient precision and to summarize the results with sufficient completeness and in sufficient detail to satisfy the needs of the great majority of readers. Each abstract should be a carefully prepared report on the contributions to scientific knowledge set forth in the article, by a scientist who feels his responsibility to his scientific colleagues to make it complete and accurate.

But why go to the trouble of preparing such abstracts? Why not let each reader glance through each article and determine what it contains for himself? Because for each scientist to do his own abstracting, as this would amount to, is as wasteful as for each to prepare his own indexes of the reference books he uses; it means not only an unnecessary duplication of effort but, worse still, a poor quality of abstracting, in most cases. Then there is the waste involved in the simultaneous abstracting of each article by several abstract journals to be considered. Efficiency demands that a good preliminary abstract be provided with each article, so that all readers may benefit by the careful work of one abstracter and none need abstract that article again.

Anyone may readily convince himself of the value of preliminary analytic abstracts if he will turn to one of the longer articles in the *Astrophysical Journal* since January, 1920, and, after spending three to five minutes in abstracting the article for himself by glancing through it, will compare the information he thus gains with what he might have obtained in an equal time from the abstract.

There can be no doubt, then, that good preliminary abstracts would save much time for scientists as readers, investigators and abstractors. But is this of any importance? Before the War many would have said, No. Research was generally regarded as a hobby. Now it is more generally realized that the research output of the country is a matter of national concern and is an important factor in national progress.

The number of scientists actively engaged in research work is relatively small. Their research time is correspondingly valuable, especially as it is further limited by the fact that most of them have teaching or executive duties which take much of their energy. Of this time the larger the part devoted to securing the necessary foundation of scientific information, both current and past, the less the part available for actual research. Therefore, everything possible should be done to make it as easy as practicable for each investigator to obtain the information he needs; that is, *our whole scientific information service, including original scientific journals, abstract journals, handbooks, tables, etc., should be made in its parts and as a whole, as efficient as possible.* All this is self-evident. In this note we are considering merely the scientific journals. Their part is to provide preliminary abstracts. And since this can be done at very small additional expense to each and since the saving of time for scientists would be in the aggregate considerable, surely there can be no question as to the advisability of the adoption of this policy by every scientific journal.

What obstacles stand in the way? The additional expense is, as just stated, small. The

abstract would be less than five per cent of the article on the average, and if the summary usually placed at the end were omitted, as could well be done because its function would be served by the abstract, the increase in length of the article would be little or nothing. But, on the other hand, the addition of abstracts would undoubtedly considerably increase the burdens of the already overburdened editors, and one would shrink from suggesting that they add to their labors the drudgery associated with securing and editing the abstracts if it were not clear that the gain to the many investigators would be many times the cost to the few.

At present, in addition to the *Astrophysical Journal, Physical Review,* and *Journal of the American Ceramic Society,* which require analytic abstracts, the following fourteen scientific and engineering journals give preliminary abstracts: The group of biological journals published by the Wistar Institute of Anatomy and Biology—*American Journal of Anatomy, American Anatomical Memoirs, Anatomical Record, Journal of Comparative Neurology, Journal of Experimental Zoology,* and *Journal of Morphology; Physiological Researches, Proc. of London Physical Society, Trans. of American Electrochemical Society, Trans. of American Institute of Electrical Engineers, Trans. of American Society of Civil Engineers, Trans. of American Society of Mechanical Engineers, Trans. of Society of Automotive Engineers,* and *Trans. of American Foundrymen's Association.* The abstracts now being provided by these journals are prepared as a rule by the authors and vary greatly in quality. It would be relatively easy for those journals whose abstracts are not as useful as is desirable to change their rules so as to require abstracts of the quality of analytic abstracts.

The directions and rules which have been formulated for the guidance of authors in the preparation of analytic abstracts may be found in current numbers of the *Astrophysical Journal* and also, somewhat abbreviated, in those of the *Physical Review* and of the *Journal of the American Ceramic Society.* With slight modification they would serve for any science. But while some authors will take the trouble to master the technique and prepare satisfactory abstracts, a uniformly high standard can not be maintained unless all the abstracts for each journal are checked and revised by a competent abstractor. Therefore, after deciding to require analytic abstracts, the first step taken by a journal should be the selection of a suitable man as abstract editor. If the man appointed should care to get in touch with me, I should be glad to give any assistance I can in getting the new policy started.

In conclusion, attention should be directed to the fact that those journals which provide analytic abstracts may easily combine an index of the subtitles in the abstracts with the usual index of author's titles, and thus greatly increase the completeness and precision of their subject indexes and hence the value of the journal for reference purposes.

It may not seem of much importance whether any particular journal provides efficient abstracts or not. Yet it is clearly the duty of each to do so. For when all have adopted this policy and the abstract journals promptly reprint all the abstracts and completely index them, we shall have gone far toward making our scientific information service really efficient. And because of the cooperation involved, it will require less effort to maintain than our present much less efficient service.

GORDON S. FULCHER
CORNING GLASS WORKS

SCIENTIFIC EVENTS

THE NATIONAL COMMITTEE ON MATHEMATICAL REQUIREMENTS

THE National Committee on Mathematical Requirements on September 5 held its last meeting under its present form of organization. The manuscript of a summary of the final report of the Committee has been sent to the U. S. Bureau of Education for publication. This summary, which will constitute a bulletin of some eighty pages, virtually presents the first part of the complete report. It contains the following chapters:

I. A Brief Survey of the Report.

II. Aims of Mathematical Instruction—General Principles.
III. Mathematics for Years Seven, Eight and Nine.
IV. Mathematics for Years Ten, Eleven and Twelve.
V. College Entrance Requirements in Mathematics.
VI. List of Propositions in Plain and Solid Geometry.
VII. The Function Concept in Elementary Mathematics.
VIII. Terms and Symbols in Elementary Mathematics.

It will also include a brief synopsis of the remaining chapters of the complete report. It is expected that this summary will appear late in November or early in December.

It was the original intention of the Committee to publish its complete report also through the U. S. Bureau of Education. It was found, however, that this would involve a delay of two or three years in view of the fact that it would have been necessary for the Bureau of Education to issue the report in parts extending over a considerable period of time. It is hoped at present that sufficient funds will be obtainable to print the report during the winter and to distribute it free of charge to all who are sufficiently interested to ask for it. The complete report will constitute a volume of about five hundred pages. In addition to the chapters listed in the summary, it will contain an account of a number of investigations instituted by the Committee. Among these may be mentioned:

The Present Status of Disciplinary Values in Education.

A Critical Study of the Correlation Method Applied to Grades.

Mathematical Curricula in Foreign Countries.

Mathematics in Experimental Schools.

The Use of Mental Tests in the Teaching of Mathematics.

The Training of Teachers of Mathematics.

There will also be included an extensive bibliography on the teaching of mathematics.

HENRY WOODWARD

We regret to record the death of Dr. Henry Woodward, F.R.S., which occurred on September 7 at his home in Bushey, England. Dr. Woodward was in his ninetieth year and in his long life had achieved very great distinction for his labors in the sciences of geology and paleontology. Dr. Woodward spent the early years of his life in business, but in 1858 he entered the British Museum, and in 1880 was made keeper of geology, a position which he held for 25 years. Though he was a profuse writer on various geological and paleontological subjects, his special interest lay in the study of the fossil crustacea, and perhaps his most keenly analytical work was in the field of the fossil merostomes. He was the president of the Palæontographical Society and had been the president of the Royal Microscopical Society as well as of the Geological Section of the British Association for the Advancement of Science and of the Geological Society of London. He was the president and founder of the Malacological Society and had been the president of the British Museums Association. In 1862, with the late Professor T. Rupert Jones, he founded the *Geological Magazine,* of which he remained the editor until the time of his death.

Doctor Woodward kept his intellectual vigor and his interest in his science up to the last and passed away peacefully after a very brief illness.

J. M. C.

PROFESSOR PAWLOW

Professor W. B. Cannon, of the Harvard Medical School, writes to the editor of the *Journal* of the American Medical Association as follows:

In *The Journal,* September 3, there is a letter from Budapest, dated July 12, 1921, in which it is stated that Pawlow, the great Russian physiologist, had died in January, 1921. You may know that several years ago there was a rumor that he had died, which proved to be incorrect. Apparently the statement from Budapest is likewise incorrect. I have a copy of a letter from Dr. Edward W. Ryan, commissioner of the American Red Cross to western Russia and the Baltic States, written from Riga, March 23, 1921, to Col. Robert E. Olds, commissioner of the Red Cross in Europe.

Dr. Ryan declares that the Red Cross was sending Professor Pawlow food and states that Pawlow's two sons, Victor and Vsevolod Ivanovitch, had not been heard from for two years and that he was very desirous of obtaining information regarding them. Again, April 24, Dr. Ryan reported that he had been able to send to Pawlow certain definite supplies which are listed. Furthermore, I have a letter from Professor Carl Tigerstedt of Helsingfors, Finland, dated July 30, 1921, in which he acknowledges the receipt of money collected from friends of Pawlow in the United States and sent to him for Pawlow's aid. The Finns have official representatives in Petrograd. Dr. Tigerstedt reports that he has been sending a consignment of food of all kinds twice monthly to Pawlow through the Finnish commission, and that he is thus not suffering any more from lack of nourishment. Nevertheless, I am sending to Dr. Tigerstedt the report from Budapest and asking for specific information regarding Pawlow's welfare.

SCIENTIFIC NOTES AND NEWS

DR. C. S. SHERRINGTON, professor of physiology at Oxford University and president of the Royal Society, will be elected president of the British Association for the meeting to be held at Hull in 1922. It is expected that the meeting of 1923 will be at Liverpool and the meeting of 1924 at Toronto.

THE International Eugenics Congress has been holding a successful meeting in New York City. We hope to publish next week the addresses given at the opening session by Dr. Henry Fairfield Osborn, Major Leonard Darwin and Professor Charles B. Davenport.

THE thirteenth course of lectures on the Herter Foundation at the Johns Hopkins University will be given by Sir Arthur Keith, F.R.S., conservator of the Museum and Hunterian professor of the Royal College of Surgeons, England. The lectures will be given on October 5, 6 and 7, the subject being "The differentiation of modern races of mankind in the light of the hormone theory."

AT the recent meeting of the American Astronomical Society, held at Middletown, Conn., Professor C. V. L. Charlier was elected an honorary member. Professor J. C. Kapteyn and Sir Frank Dyson are the only other living astronomers who have been thus honored.

PROFESSOR ROBERT W. HEGNER, of the department of medical zoology, school of hygiene and public health, Johns Hopkins University, has been elected a fellow of the Royal Society of Tropical Medicine and Hygiene, London, England.

DR. HEBER W. YOUNGKEN, professor of botany and pharmacognosy in The Philadelphia College of Pharmacy and Science was elected chairman of The Scientific Section of The American Pharmaceutical Association at its sixty-ninth annual convention held in New Orleans, from September 5–9.

WILLARD ROUSE JILLSON, director and state geologist of the Kentucky Geological Survey with offices at Frankfort, Kentucky, received the doctorate of science from Syracuse University at its fiftieth commencement last June.

PROFESSOR J. J. THORNBER has been appointed director of the Agricultural Experiment Station of the University of Arizona, at Tucson, and began his work on September 1. Professor Thornber has completed twenty years' continuous service as head of the department of biology in the College of Letters, Arts and Sciences, University of Arizona, and henceforth will devote his time to administrative work and investigation.

PROFESSOR R. J. TERRY, of the department of anthropology of Washington University, Saint Louis, has been appointed anthropologist to the Barnes Hospital and Saint Louis Children's Hospital.

DR. MICHAEL F. GARDNER has been appointed chief of the Bureau of Preventable Diseases and director of the bacteriological laboratory of the U. S. Public Health Service.

THE Fixed Nitrogen Research Laboratory, together with about a half million dollars from the original appropriation made for the investigation of nitrogen fixation, was transferred on June 30 from the jurisdiction of the War Department to the Department of Agriculture. The laboratory is now an independent unit of the Department of Agriculture, under the direction of Dr. Richard C. Tolman, who has the assistance of an advisory committee

made up of a representative of the War Department and representatives of the agricultural bureaus which are directly interested in the fixation of nitrogen. It is expected that the present allotment will maintain the laboratory for about two years.

The Sections of Eastern and Western Areal Geology in the U. S. Geological Survey have been merged into one section under the direction of Mr. Sidney Paige.

Upon nomination of the French Government, the Harvard University corporation has appointed Emile F. Gautier, professor of geography in the University of Algiers, as the French exchange professor at Harvard this year. He will lecture at Harvard during the second half-year. Professor Maurice DeWulf, who was one of the Louvain University (Belgium) teachers invited to Harvard after the destruction of the university by the Germans in 1914, has now been invited to return on a permanent appointment as professor of philosophy.

M. J. Cavalier, professor of metallurgy in the University of Toulouse, has arrived in New York City to take up his work as French exchange professor at Columbia University. He will be at Columbia from October 1 to October 30. Professor Cavalier, rector of Toulouse University, known as an authority on metallurgical chemistry, comes to America as the result of arrangements for an annual exchange of professors of engineering and applied science between French and American universities. Professor Cavalier will divide his time among Columbia, Harvard, Yale, Cornell, Johns Hopkins, Massachusetts Institute of Technology and the University of Pennsylvania.

Professor Reginald A. Daly and Professor Charles Palache of Harvard University are members of the Shaler Memorial Expedition to South Africa. A large part of Dr. Daly's work will be conducted by Dr. Eliot Blackwelder, chief geologist of the Argus Oil Company at Denver.

The British Tropical Disease Prevention Association is sending out a mission under Dr. Claude H. Marshall, a senior medical officer in Uganda, whose services are being lent by the government of Uganda for that purpose, to investigate certain methods of treating trypanosomiasis.

Professor S. Kato, Keio University Medical College, Japan, plans to visit colleges and laboratories in Germany, Austria, Denmark, Belgium, France and England. He expects to return to Japan by way of America. He expected to leave Japan on September 30.

Mr. F. W. L. Sladen, the well known authority on bees, and author of "The Humble-Bee," was accidentally drowned at Duck Island, Lake Ontario, on September 10. Mr. Sladen was carrying on research work in bee breeding on this island.

In memory of the late Dr. Susumu Sato, who devoted his life to the progress of medical science in Japan, a laboratory will be constructed at a cost of 300,000 yen, for the Yuntendo Hospital, the largest private hospital in Japan. Courses in every branch of medical science will be offered under the presidency of Dr. Susumu Nukada, and clinics will also be held in the institution.

We learn from the *Journal* of the Washington Academy of Sciences that at the invitation of Mr. Northcott, owner of the Luray Caverns, Virginia, Dr. Ales Hrdlicka of the National Museum has visited the caverns for the purpose of examining and removing certain bones, enclosed in stalagmite, which were believed to be human. After considerable difficulties, the entire deposit containing the bones was taken out in pieces which showed the remains of most of the parts of a human skeleton; but no trace remained of the skull with the exception of a portion of the lower jaw. The specimens have been given to the museum for further study.

It has been finally decided to hold the International Congress for Comparative Pathology at Rome, beginning on September 20, 1922, under the presidency of Professor Perroncito. The *Riforma Medica* of August 13, 1921, gives the list of twenty subjects appointed for discussion, and communications

on other subjects are invited by Professor Perroncito, whose address is R. Universita di Torino.

The British Medical Journal reports that at the second Congress of the History of Medicine in Paris last July it was agreed that the third Congress, to be held in July, 1922, should take place in London. There will be a meeting for business purposes towards the end of this year in Paris, which will be attended by Dr. Charles Singer, president of the Section of the History of Medicine of the Royal Society of Medicine, when the permanent organization of the congress will be discussed. A meeting of the Section of the History of Medicine will be held on October 5, to forward the arrangements for the London Congress of 1922.

THE *Journal* of the American Medical Association reports that the purpose of the Belgian University Foundation, which was established by law, July 6, 1920, is the advancement of science and learning: (1) by granting to young Belgians who are gifted but are without financial resources loans that will allow them to take up university studies; (2) by granting financial aid to scientists and to young men who are planning to teach higher subjects or to undertake scientific researches, and (3) by encouraging scientific relations between Belgium and other countries. With the last mentioned aid in view, the foundation will aid physicians engaged in medical instruction in foreign countries. It will keep in close touch with the Association pour le développement des relations médicales de la faculté de médecine de Paris, the Office national des universités françaises, the Universities Bureau of the British Empire, the American University Union and the Junta para ampliación de estudios de Madrid.

IT is announced in *Nature* that the Ministry of Agriculture and Fisheries and the Royal Horticultural Society have arranged to hold an International Potato Conference in London on November 16–18 next. During the conference, which will take place at the hall of the Royal Horticultural Society, Vincent Square, the National Potato Society will hold its annual show, at which it is expected that most British varieties of potatoes will be exhibited. An exhibit dealing with the scientific aspect of potato problems is also being arranged, and it is hoped that workers engaged on potato problems in all parts of the world will cooperate. The proceedings will open with Sir A. Daniel Hall's presidential address on the morning of November 16. Papers on the breeding and selection of potatoes in Great Britain and the United States, and on wart disease, potato blight, and other diseases which are botanically and economically important, will be read, and time has been allowed for their discussion. Invitations to attend the conference have been extended to the Dominions and Colonies and to foreign countries, and it is hoped that the meeting will be throughly representative from both the scientific and the commercial aspects.

WITH the approach of cold weather renewed activity in the radio market news service is planned by the Bureau of Markets and Crop Estimates, United States Department of Agriculture, for the eight months beginning October 1. Atmospheric conditions are unfavorable to radio communication in warm weather, and many amateurs and experimenters discontinue their operations during the summer. It is expected, however, that with the coming of autumn the interest in radio activity will increase. Many states have shown keen interest in the development of radio news service covering market, crop and weather reports. State cooperation is planned by the bureau and will be taken up with the various states within range of the radio stations. The states that cooperate will be asked to determine the agency or agencies that are to work with the federal bureau in order to prevent duplication of effort. The handling of news matter will necessarily vary with the different states, depending on administrative organizations, geographical position, climate, and other factors.

CORN that grew in Tennessee in pre-historic times was unearthed recently by W. E. Meyer, of the Bureau of American Ethnology, and sent to the United States Department of Agricul-

ture for identification. During recent excavations in Davidson County, Tenn., Mr. Meyer came upon a number of stone slab graves containing mortuary vessels. Some of these held specimens of charred maize in fairly good condition. From the size and shape of the grains it was possible to identify the variety as Many-Rowed Tropical Flint, a form about half way between true flint and popcorn. The same type of Indian corn occurs in the West Indies, and there appears to have been a very early communication between the West Indies and North America. Not only corn but beans, squashes, pumpkins, and tobacco are of tropical and subtropical origin. These staples, now so important throughout both hemispheres, found their way into North America and were cultivated beyond the Great Lakes in Canada long before the discovery of America. There is abundant evidence of communication between the West Indies and Florida, and up the Mississippi and its tributaries.

The *Brazil Medico* announces that Dr. Cleef, professor of chemistry at Bello Horizonte, reports the discovery in Minas Geraes of a mineral substance hitherto unknown which possesses great radioactive properties.

UNIVERSITY AND EDUCATIONAL NEWS

Yale University has begun the construction of the new Sterling Chemical Laboratory. It is hoped that this building will be ready for the use of the department of chemistry in October, 1922.

New members of the faculty at the University of North Carolina, at the beginning of the fall term include G. M. Braune, professor of civil engineering; H. B. Anderson, associate professor of pathology; H. F. Janda, associate professor of highway engineering; F. C. Vilbrandt, associate professor of industrial chemistry; H. W. Crane, associate professor of psychology, and E. L. Mackie, assistant professor of mathematics,

Miss Edith Nason, Ph.D., Yale, 1921, has been appointed an instructor in organic chemistry at the University of Illinois.

Mr. Henry R. Henze, who received his Ph.D. degree from Yale in June, 1921, has become adjunct professor of chemistry in the medical school of the University of Texas at Galveston.

DISCUSSION AND CORRESPONDENCE

A NEW DEFINITION OF PURE MATHEMATICS

During the present year there appeared a volume of the *Acta Mathematica,* volume 38, which was dedicated to the memory of H. Poincaré, the noted French mathematician who died in 1912. This volume opens with an account of his own works by Poincaré in which he deals briefly with his own contributions to the advancement of various subjects. This is followed by a report on the theory of groups and the works of E. Cartan, which Poincaré read before the council of the faculty of sciences of the University of Paris on the eve of the operation resulting in his death. The rest of the volume is devoted to letters and to various articles written by others but relating to Poincaré and his works.

In the present note we desire to direct attention to the second article mentioned above, which seems to be one of the last articles, if not the last article, written by Poincaré, and contains some remarkable statements in regard to the theory of groups. One of these is as follows: "The theory of groups is, so to say, entire mathematics, divested of its matter and reduced to a pure form." The interest in this statement should be increased by the fact that it may be regarded as a new definition of pure mathematics, the skyscraper among scientific structures. One of the best known other definitions is due to B. Peirce, who stated that "mathematics is the science which draws necessary conclusions." It should, however, not be inferred that the latter definition has been generally accepted as an entirely satisfactory one, nor do we want to create the impression that the former is likely to be universally adopted.

It may, however, be a matter of wide interest to see what Poincaré meant by the statement quoted above. Such an insight can probably be best gained by reading his own

preliminary remarks, which are, in part, as follows:

> The preponderant rôle of the theory of groups in mathematics has been unsuspected for a long time. Eighty years ago even the name of group was unknown. It was Galois who first had a clear notion of it, but it is only since the works of Klein, and especially of Lie, that one has begun to see that there is almost no mathematical theory in which this notion does not occupy an important place. . . . It is necessary to give the same name to different things, but on condition that these things are different as to matter but not as to form. What is the cause of the mathematical phenomenon so often constant? And, on the other hand, of what consists the community of form which subsists under the diversity of matter? It is due to this that every mathematical theory is, in the last analysis, the study of properties of a group of operations, that is to say, of a system formed by certain fundamental operations and of all the combinations which can be made therefrom.
>
> If, in another theory, one studies other operations which combine according to the same laws one will naturally see a set of theorems, having a one to one correspondence to those of the first theory, unfold themselves, and the two theories may be developed with a perfect parallelism; an artifice of language like those of which we just spoke, suffices to make this parallelism manifest and to give almost the impression of a complete identity. One says then that the two groups of operation are isomorphic, or that they have the same structure. If then one divests the mathematical theory of this which appertains to it only by accident, that is to say, its matter, there will remain only the essential, that is to say, the form; and this form, which constitutes, so to say, the solid skeleton of the theory, will be the structure of the group.

G. A. MILLER

UNIVERSITY OF ILLINOIS

GALL EVOLUTION: A NEW INTERPRETATION

PRACTICALLY all gall students to date have regarded cecidia as responses to specific stimuli relating specific differences causally to the plant bearing the gall.

Basing his ideas on Küster's logical classification of galls (structurally considered) into "kataplasmas" (galls of indefinite character; ex. oak knot gall, *Andricus punctatus* Bass.) and "prosoplasmas" (galls of definite character; ex. oak apple, *Amphibolips inanis* O. S.) together with Cook's recognition of the influence of the animal in gall formation, the writer has developed a new theory of gall evolution.

The new interpretation holds that phylogenetically prosoplasmas have been derived from kataplasmas. Further, kataplasmic evolution involves progressive inhibition of the normal differentiation of the plant part until homogeneity is reached. Not until kataplasmic evolution has been completed is it possible for prosoplasmic evolution to begin its course in which fundamentally new tissue orientations and forms are produced. Thus from the standpoint of the plant's differentiation we have first a regressive movement (kataplasmic) and then a progressive one (prosoplasmic) but from the standpoint of the animal the series should be regarded as progressive throughout.

A corollary of the above interpretation is the striking situation that an animal may not only inhibit the expression of a plant's characters but may introduce new ones, or in other words the evolution of the animal induced galls (zoocecidia) is primarily or fundamentally related to the animal. The initiating changes producing the different gall types probably occur in the germ plasm of the animal. This means that the evolution process carried out in the animal comes to expression in the plant, an interesting situation to say the least.

The evidence for the above theory drawn from the fields of comparative morphology and embryology appears to the writer to be overwhelming.

The writer has presented this thesis at greater length in the May, 1921, number of the *Botanical Gazette*.

B. W. WELLS

NORTH CAROLINA STATE COLLEGE

ON SOUNDS ACCOMPANYING AURORAL DISPLAYS

TO THE EDITOR OF SCIENCE: The existence of sounds in connection with manifestations of the aurora is regarded by many as still a

moot point, *cf.* the remarks at the close of the article on the subject in the Encyclopedia Britannica.

Several observers have reported hearing such sounds during the very brilliant auroral display of May 14. I could not detect any such sounds on this occasion, doubtless owing to the proximity of a large city from which the volume of sound, even at 3 A.M., is quite noticeable.

I desire to place on record, however, certain earlier experiences under almost perfect conditions of isolation and quiet. While in charge of the Labrador station of the Lick Observatory-Crocker Eclipse Expeditions of 1905, much of the work of adjusting the instruments was necessarily done at night. The station was located at Cartwright (latitude +53° 42′), and auroral displays were frequent and bright during July and August. On several nights I heard faint swishing, crackling sounds which I could attribute only to the aurora. There were times when large faintly luminous patches or "curtains" passed rapidly over our camp; these *seemed* to be close and not more than a few hundred feet above the ground, though doubtless much higher. The faint hissing and crackling sounds were more in evidence as such luminous patches swept over us.

Heber D. Curtis
Allegheny Observatory,
August 10, 1921

LAWRENCE'S WARBLER

To the Editor of Science: It may be worth while to record the presence of the rare *Vermivora (Helminthophila) lawrencei* (Herrick) in Lexington, Virginia, on May 14. The warbler was observed sitting on a telephone wire less than ten yards from the porch of a house just on the outskirts of town, and its conspicuous black throat patch and white wing bars served to fully identify it, and differentiate it from *V. pinus* and *V. chrysoptera,* of which it is supposed to be a hybrid. Chapman speaks of it as much rarer than Brewster's warbler, *V. leucobronchialis,* the other supposed hybrid of these species, and says that less than a dozen specimens have been recorded.

Jas. Lewis Howe
Washington and Lee University,
Lexington, Virginia

QUOTATIONS

CHEMISTRY IN WAR

Two distinguished chemists have recently made pronouncements, identical on the material side, divergent on the moral side, on the use of posion gas in war. It is a question on which civilization will have to come to a decision or to live under lasting and increasing menace. Sir T. Edward Thorpe, in his presidential address to the British Association, at Edinburgh, told his audience that the Germans, between April, 1915, and September, 1918, had used no fewer than eighteen different forms of poison—gases, liquids, and solids—in their military operations. Reprisals became inevitable, and for the greater part of three years the leading nations of the world were flinging the most deadly products at one another that chemical knowledge could suggest and technical skill contrive. Sir William Pope, an equally eminent English chemist, speaking at Montreal a few days before, said that by the Armistice the Allies had sufficient supplies of mustard gas to "have enveloped the Germans knee deep, and had discovered a new vapor against which respirators would be of no avail, so strong that it would stop a man if it were present in the atmosphere in the proportion of one part in five millions." The President of the British Association admitted that warfare had now definitely entered on a new phase. But in passionate words he deplored the prospect on the part of science and of humanity, and hoped that, through the League of Nations or by some other form of international agreement, it might be averted. Sir William Pope, on the other hand, claimed that from the humanitarian point of view gas was more merciful than high explosives, and stated his belief that chemical agencies would be the sole deciding factor in future wars.

Certainly even the eighteen poisons used by the Germans and the counter-efforts actually brought into operation by the Allies were the fumbling of experimental amateurs compared with what might follow a new outbreak of hostilities between great manufacturing and scientific nations. Poison could suddenly extinguish all life over so many square miles of territory, over a walled city, or a navy in its harbor. Science could provide the formula, industrial chemistry the substance, and aeroplanes the means of distribution. Were poison gas a specialized and secluded branch of chemistry there might be some hope that science might refuse to pervert its high mission from the service to the destruction of mankind. But such a possibility does not arise, because the discovery of noxious substances is an inevitable side issue of the pursuit of chemical knowledge. The world must either face and prepare for the future, or it must prohibit chemical warfare by an international agreement supported by effective international sanctions.—The London *Times*.

SCIENTIFIC BOOKS

BIBLIOGRAPHY OF RELATIVITY

THE great interest in any scientific or philosophic discovery generally calls forth semi-scientific and learned discussion, followed by a demand for literature, historical and recent, upon this particular subject.

The literature of the theory of relativity is recent and more or less familiar to the scientist. Before 1905, the year in which Dr. Albert Einstein brought forward his fundamental and special theory, the literature was scattered and bore indirectly upon the theory of relativity as we know it to-day. The literature is quite extensive, however, from 1905 to the time of the British solar eclipse expedition in May, 1919, the results of which placed the theory of relativity in a more or less acceptable light, that is, the mathematical and physical aspects found verification in the astronomical interpretations.

In view of the fact that the subject of relativity will probably have great influence upon future problems in physics and astronomy, due to its mathematical character, and that the history of this development can best be served when the literature is known and organized, a bibliography should prove of great value.

The present note is to call attention to the fact that an extensive and as complete a bibliography as is possible, is in process of being compiled. And thus far the writer has collected approximately one thousand titles of books, pamphlets, articles and notes published in all languages to which it is possible to obtain access. The John Crerar Library seems the most logical place to form this bibliography due to its great collection of scientific literature. The philosophical literature bearing upon this question (relativity) fortunately falls within the scope of the library's collection.

It is hoped that each entry upon the typewritten card will contain, besides the author, title, source, date, also a short abstract, note or review indicating just what the principal idea is that the author has conveyed. A mere author-title list is for current use and answers only half of what a true bibliography ought to be, and therefore is quite unsatisfactory. Over 90 per cent. of the titles represent material in The John Crerar Library, and it is planned to make the collection in the library as complete as possible, bearing upon relativity.

The question of publishing this bibliography is a difficult one, and at present no provision has been made for it.

What form of bibliography will be most valuable for scientific purposes is an open question. There are as many types as there are demands for certain use. An alphabetical author-title list serves one certain demand, and a chronological author-title list serves another. One might be analytical and another synthetical in its aspect. A synthetical bibliography must be selective, critical and constructive [1]; add to this abstract, notes and reviews, and it would be a bibliography worthy of its name.

[1] Dr. George Sarton, *Isis*, III., 159–170, No. 8, Autumn, 1920.

From the point of view of the future historian this would serve as a large labor-saving device, especially in view of the fact that human knowledge is ever becoming more specialized.

It might be well to call attention to the fact that a bibliography of relativity has also been in progress in England,[2] namely, the International Catalogue of Scientific Literature, under the direction of Dr. H. Forster Morley. Dr. Morley has made a selected chronological bibliography of relativity and related problems from 1886 to the end of 1920.

The recent visit of Dr. Albert Einstein has not alone stimulated interest among scientific men, but he has strengthened his theory by his own clear presentation of relativity.

Of course the theory has yet to receive its final verification, before the whole can be accepted, and Dr. Einstein has expressed confidence in the final answer.

Not since the doctrine of evolution was promulgated, has any advance of intellectual progress, either of philosophic or scientific importance, caused such profound interest, popular or scientific, as the theory of relativity. And like all epoch-making ideas, the synthetical character of the theory of relativity will mark off a period of great importance in the history of science. Hence the value of a bibliography of a subject in relation to the history of science is in direct proportion to the importance of the subject itself.

Frederick E. Brasch
The John Crerar Library,
Chicago, Illinois

SPECIAL ARTICLES

EINSTEIN'S COSMOLOGICAL EQUATIONS

In two earlier notes published in Science (Vol. 52, p. 413, Vol. 53, p. 238) I gave certain geometrical theorems connected with Einstein's original (1914) equations of gravitation, $G_{ik}=0$ (in space free from matter). I shall now extend some of the results so as to apply to the modified equations employed in Einstein's cosmological speculations. These he first wrote (1917) in the form, $G_{ik}-\lambda g_{ik}=0$; but more recently (1919) he has employed the form $G_{ik}-\frac{1}{2}g_{ik}G=0$, which includes the previous form and which, when the energy impulse tensor T_{ik} is introduced in the right hand member, has the advantage of being possibly applicable to the microcosm (atoms and electrons) as well as to the macrocosm (the stellar universe). Here G_{ik} is the contracted curvature tensor and G is the scalar curvature.

For brevity we shall term any four dimensional manifold which obeys the last equations, a cosmological solution.

I. The only cosmological solutions which have the same light rays as the euclidean or Minkowski world are those which have constant curvature in the sense of Riemann. In other words, if a cosmological world is to admit conformal representation on a euclidean world, it must be of spherical (or pseudo-spherical) character. This result is analogous to the earlier result for $G_{ik}=0$, that the only manifolds having the Minkowski light equation are flat (zero curvature). Both results are obviously valid also for geodesic representation (same equation of orbits).

II. Here we discuss four-dimensional curved manifolds which can be regarded as imbedded in a flat space of five dimensions. Our result is that for the cosmological equations, there are two distinct possibilities.

(*a*) In the first case at every point of the manifold the four principal curvatures are equal, that is $K_1=K_2=K_3=K_4$, so that every point is umbilical. The manifold is then simply a hypersphere.

(*b*) In the second case $K_1=K_2=-K_3=-K_4$, that is, the four principal curvatures are numerically equal, but two are positive and two are negative. Such manifolds may be regarded as a generalization of ordinary minimal surfaces (where $K_1=-K_2$), and may be described as hyperminimal spreads. (It would be interesting to find an actual example in finite form of such a spread.)

It will be recalled that for our previous discussion of $G_{ik}=0$, no solution in five dimen-

[2] Dr. H. Forster Morley, *Nature*, 106, 811–13, Feb. 17, 1921.

sions existed, the simple case of the solar field being actually six dimensional,[1] as are also certain other physical solutions obtained by Weyl.

III. The author has found all solutions of $G_{ik}=0$ of the orthogonal form $\lambda_1 dx_1^2 + \lambda_2 dx_2^2 + \lambda_3 dx_3^2 + \lambda_4 dx_4^2$ in which the four coefficients are functions of one variable say x_1. An example of such a field is

$$x_1^{-2} dx_1^2 - x_1^4 (dx_2^2 + dx_3^2 + dx_4^2).$$

All cosmological solutions which satisfy the same hypotheses are determined and can be expressed by elementary, algebraic and transcendental functions.

The principal solution is

$$ds^2 = \frac{4dx_1^2}{c^2(1+x_1^2)^2} + \left(\frac{2x_1}{1+x_1^2}\right)^{\frac{2}{3}} \left[x_1^{2a_2} dx_2^2 + x_1^{2a_3} dx_3^2 + x_1^{2a_4} dx_4^2\right],$$

where c is arbitrary and a_2, a_3, a_4 obey the relations.

$$a_2 + a_3 + a_4 = 0, \qquad a_2 a_3 + a_3 a_4 + a_4 a_2 = -\tfrac{1}{3}.$$

These fields can all be represented in flat space of seven dimensions. A paper on this subject has been sent to the *Mathematischen Annalen*.

IV. If we require the quaternary form ds^2 to be the sum of two binary forms, that is the sum of the squared elements of two surfaces, then the only cosmological solution (neglecting the trivial euclidean form) is $ds^2 = x_1^{-2}(dx_1^2 + dx_2^2) + x_3^{-2}(dx_3^2 + dx_4^2)$. This represents a quartic manifold of four dimensions imbedded in a 6-flat. The finite equations are

$$X_1^2 + X_2^2 + X_3^2 = 1, \; X_4^2 + X_5^2 + X_6^2 = 1.$$

This is apparently the simplest solution of Einstein's equations which has thus far been found, and the first one (beyond the obvious flat and spherical spaces) which in its finite form is algebraic.

EDWARD KASNER

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[1] See *American Journal of Mathematics*, Volume 43 (1921), pp. 126–133.

THE PRODUCTION OF ENHANCED LINE SPECTRA BY A NEW METHOD

THE ordinary spark spectrum differs from the arc spectrum in that certain lines are weakened, others are enhanced and new lines appear. In general the more violent the stimulus of the source the more intense are the new enhanced lines as compared to the weakened lines. It is customary to refer to the lines which are the more prominent in the spectrum produced by an arc as arc lines, while those which are enhanced by the spark are known as spark lines and constitute the pure spark spectrum.

Lorenser and Fowler, as well as Sommerfeld and Kossel, have shown that modern theories of atomic structure and radiation leave little doubt that the enhanced lines in the spectrum are due to radiation from atoms that have lost an electron, *i.e.*, ionized atoms; and that arc lines are due to radiation from the un-ionized or neutral atom. The varying facility of producing the enhanced lines of different elements depends, then, on the intensity of the forces which bind the electron to its nucleus and on the energy used in tearing the electron off. For example, no enhanced lines of lithium have ever been produced while the enhanced doublet of calcium, H and K, is strong even in the flame spectrum.

In a study of the enhanced lines of the calcium spectrum begun by examining the spectrum of calcium wires exploded by the Anderson method[1] it was found that as the size of the wires used was decreased, while the energy of the stimulus remained the same, the intensity of the enhanced lines increased. This increase in intensity indicated a more complete ionization of the calcium atoms. In seeking a way by which the amount of calcium in the source could be still further reduced a new source of light was developed.

A fine asbestos fiber about three centimeters long was saturated with an aqueous solution of some salt of calcium. The saturated fiber was fastened in place as the fine wires had previously been fastened and the charge of the high tension condensers thrown across it,

[1] *Astro. J.*, 51, 37, 1920.

as before. The fiber was not injured by the discharge but could be saturated and used again and again. About the same number of discharges as had been employed with the exploded wires produced satisfactory results. For convenience in discussion and because of its character this new light source has been tentatively called the super spark.

An inspection of the calcium spectrum thus produced showed a striking enhancement of the spark lines of calcium over the arc lines indicating that a large proportion of the emitting atoms were ionized. For the purposes of comparison a table is inserted showing for the present work with the exploded wire and super-spark and for the work of other observers with various sources—the relative intensities of the H and K lines of calcium, a prominent spark doublet, and the line 4227, a strong arc line. The ratio of these intensities is, we believe, a fair index of the relative proportions of ionized and unionized emitting atoms in the source.

THE RELATIVE DEGREE OF IONIZATION OF CALCIUM IN DIFFERENT SOURCES

Source	Intensity of H and K	Intensity of 4227	Ratio of Intensities
King's electric furnace	55	1000	1:19
Crew & McCauley arc	400	500	4:5
Lockyer spark	500	400	5:4
Loving vacuum arc	20	8	5:2
Exploded wire	600	150	4:1
Super spark	700	70	10:1
High chromosphere of sun	72	8	9:1
Class B stars	7	1	7:1

This table indicates that there can be produced in the laboratory the same degree of ionization as is shown to exist in the high chromosphere of the sun or in the spectra of the early (or hot) type B stars. The super spark seems to give a more highly ionized source than any yet produced in the laboratory.

The results of an extended study soon to be published of the super spark spectra of calcium and other metals may be briefly summarized here. For the metals studied in the groups one, two and three of the periodic table, an almost pure enhanced line or spark spectrum has been produced. As might be expected it has been impossible to get perfect ionization even in this source and the strongest lines due to the neutral atom still persist. A striking feature of the super spark is the amazingly small amount of material required to produce spectra. By use of a dilute solution of calcium chloride for example there is produced not only the calcium spectrum but also the spectrum of the other metals of the same group: Magnesium, barium, strontium, zinc and cadmium; and generally a few lines of other metals. These other metals could have been present only in minute amounts and yet their spectra rival in intensity that of the principal substance. Another striking characteristic is that practically only metallic lines are produced by the super spark,— the spectra of hydrogen, oxygen or of the acid radical of the salt used do not appear, and only the strongest air lines can be identified.

The super spark, it will be seen, gives a method by which a very powerful stimulus can be applied to any metal that can be obtained in the form of any of its partially soluble salts. It is not even necessary that the metal in question be the principal metallic constituent of the salt. Good results may be obtained for metals which appear only as minor impurities in the salt used.

R. A. Sawyer,
A. L. Becker

Physical Laboratory,
University of Michigan,
August 11, 1921.

THE IOWA ACADEMY OF SCIENCE

The thirty-fifth annual session of the Iowa Academy of Science was held at Simpson College, Indianola, on April 29 and 30. At the opening meeting on Friday afternoon President Knight gave his presidential address on "American science." The Academy divided into sections of botany, zoology, geology, and physics for the reading of papers, and at 5 o'clock adjourned for an enjoyable auto ride given by the Indianola Chamber of Commerce. At 6 o'clock the sections met for group dinners and at 8 o'clock Dr. J. Paul Goode of the University of Chicago, addressed the

Academy on "America as a world power." Following the address President and Mrs. Hillman of Simpson held a reception for the visitors.

On Saturday morning the sections concluded the reading of papers and the Iowa sections of the American Chemical Society and the Mathematical Association of America held their meetings. At the business meeting the constitution was revised to drop the classes of corresponding fellow and corresponding associate. Members are to be classed as honorary fellows, life fellows, fellows and associates. Six sections of the Academy are provided for and the chairmen of these, with the elected officers, constitute the executive committee. An editorial committee is provided for to assist the secretary in preparing manuscripts for publication. Officers were elected as follows: *President,* D. W. Morehouse, Drake University, Des Moines; *Vice-President,* R. B. Wylie, State University, Iowa City; *Secretary,* James H. Lees, Iowa Geological Survey, Des Moines; *Treasurer,* A. O. Thomas, State University; *Presidents of Sections: Botany,* R. B. Wylie; *Zoology,* Harry M. Kelly, Cornell College, Mount Vernon; *Geology,* A. C. Trowbridge, State University; *Physics,* L. P. Sieg, State University; *Chemistry,* P. A. Bond, State University; *Mathematics,* W. J. Rusk, Grinnell College, Grinnell.

The following program was presented:

CHEMISTRY

Further work in the study of free energy of aqueous solutions: J. N. PEARCE and H. B. HART.

The effect of relative positions of the hydroxide and amino radicals in the migration of acyl from nitrogen and oxygen: L. CHARLES RAIFORD and H. A. IDDLES.

A chemical study of dolomites: NICHOLAS KNIGHT.

Twenty-seven specimens were included in the investigation. They belonged to different parts of the United States and to a number of foreign countries. It was found that the term *dolomite* is rather loosely used, as the specimens ranged all the way from fairly typical dolomites to ordinary limestones. Indeed, some of the specimens proved to be quite pure sandstones.

A brief review of the various methods of producing dolomite artificially was included in the paper.

GEOLOGY

Three glacial tills at Ames, Iowa: JOHN E. SMITH. This illustrated paper treats of the character of these deposits and of their relations to each other. The observations were made in a large excavation opened to receive the foundation of Wesley Hall just south of the grounds of Iowa State College on Lincoln highway. At this place most of the Wisconsin till had been removed by erosion prior to the beginning of this work. A zone of red soil separates it near the top of the pit from the Kansan below. Beneath the Kansan which covers a rough, eroded surface, is a third till believed to be the Sub-Aftonian or Nebraskan.

Eolian deposits in Webster county, Iowa: JOHN E. SMITH. The location, distribution and origin of a deposit which overlies the Wisconsin till in this area is discussed in the paper. A typical section shows one foot or more of each of the following which are named in order of their occurrence from the surface downward: *Section:* (1) Clay, gray, with no pebbles. (2) Soil, a black zone of humus with few pebbles. (3) Subsoil, brown, with glacial pebbles. (4) Glacial till, unweathered. The principal question involved concerns the origin of number 1 of the section, which one authority holds to be free from glacial pebbles because of a postulated advanced stage of weathering.

The existing stage of erosion in the United States: ARTHUR C. TROWBRIDGE. Inspection of 398 topographic maps published by the U. S. Geological Survey since 1912, and representing 41 of the states of the Union, reveals no illustration of any considerable area of surface which has been reduced to old age of a cycle of erosion by the work of streams. Old valleys are fairly abundant but no general surface is found which can be said to have been baseleveled or even peneplained. This is interpreted to mean that the present time was so closely preceded by uplift and enlargement of land that there has not since been time for streams to reduce the surface beyond maturity, or at best, beyond early old age. Either the Pleistocene period was too short to permit land uplifted in the latest Tertiary to be greatly reduced—an explanation which seems unlikely to the writer—or there has been Pleistocene or post-Pleistocene uplift.

Some north-south topographic profiles in the United States: ARTHUR C. TROWBRIDGE and JOHN T. LONSDALE. That part of the surface of North America which was not covered by the Pleistocene ice sheets was, during the glacial period, subject to the ordinary processes by which land is de-

graded or renewed. On the contrary not only was stream degradation repeatedly interrupted in the glaciated area, but the surface there was repeatedly eroded glacially, and as many times received glacial deposits. Thinking that these differences in Pleistocene history between the glaciated and unglaciated parts of the continent might have resulted in profiles notably discordant at or near the drift border, a series of meridional topographic profiles was drawn from the Canadian border to the Gulf of Mexico. The results are negative in that no topographic break is shown at the line separating the glaciated from the unglaciated area, but on the whole the surface near the drift border to the south is higher than that to the north. The paper consists of a presentation of these profiles and discussion of several possible interpretations of their meaning.

Interglacial volcanic ash: Charles Keyes. During the progress of extensive street grading in the city of Des Moines, recently, there was disclosed immediately under the Wisconsin till sheet, a white, claylike bed about a foot in thickness. It manifestly did not belong with the drift or the yellow loess beneath. Since the material was too incoherent to be true clay, and was finely gritty, it was examined under the microscope. It proved to be typical volcanic ash, composed of transparent, sharp-edged fragments of glass about one twentieth of a millimeter in average size. The thick loess deposit underneath is underlaid by the Kansan till. This occurrence probably fixes, within very narrow limits, the date of the volcanic outburst, and the age of similar ash beds reported in Nebraska, Colorado and Wyoming.

Erosion of high plateaux: Charles Keyes. The lofty, flat-topped mountain ranges of eastern Utah are usually treated as part of the great Cordilleran uplift. Curiously, they now appear both physiographically and tectonically to be wholly unrelated. Although the repeated uplifting and peneplanation which the Rockies have suffered are appreciably reflected in the Utah field the amount of erosion which the former has undergone enormously surpasses that of the latter. Notwithstanding the fact that both chains of mountains are characterized by remnantal summital flats, the latter seem to be nicely separated in point of time. On the one hand the summital plain of the Rockies appears to be ancient Comanchan peneplain now being exhumed as the Dakotan sandstone is being stripped off. On the other hand the *terre pleins* of the High Plateaux of Utah are referred to the regional planation of Miocene times. In the Cordilleran region these two horizons are stratigraphically separated by more than three miles of sediments. The Jurassic-Comanchan peneplain of the Rockies is strongly reflected so far east as Iowa and Minnesota; as is also the Miocene peneplain of Utah.

Crazing of mountain massifs: Charles Keyes. The central *massif* of the Sierra de los Cucaras, in Lower California, is a granitic type of rock not very unlike that of the Sierra Nevada. Its naturally blue-gray color darkens on exposure, thus bringing out in strong contrast the wonderful veining, which is white. The veining in the vertical walls of the mountain canyons has the appearance of normal jointing set on edge, but on a colossal scale, the cross-planes being filled with pegmatitic materials to a thickness of two to six feet. Towards the north end of the mountain range the titanic crazing is displayed in superb sections 1,500 feet high, in the famous Carriso Gorge, near the United States boundary.

Some Pleistocene sections at Des Moines: James H. Lees.

Some Carboniferous protozoa: Eula D. McEwan.

The status of certain Rynchonellid Brachiopods from the Iowa Devonian: A. O. Thomas and M. A. Stainbrook. The *Rynchonella alta* Calvin from the upper Devonian beds at Bird Hill, Hackberry Grove, and elsewhere in Floyd and Cerro Gordo counties, has been much confused in the literature and in collections with a similar rhynchonellid shell from the State Quarry beds near Solon. In most cases in the Iowa reports the Solon species has been called *Rhynchonella pugnus* or *Pugnax pugnus* (Martin). In some instances the two have been entered under the same specific name and in others the first has been made a varietal form of the second. A study of their internal structures by Mr. Stainbrook shows that each belongs to the genus *Pugnoides*. They are specifically distinct. The more robust but less acuminate State Quarry shell, with a variable number of plications on its fold and sinus, is made a new species, *Pugnoides solon*, and the Lime Creek species becomes *Pugnoides altus* (Calvin). Illustrations.

A Cephalopod from the Coal Measures at Mystic, Iowa: A. O. Thomas. A fine specimen of the goniatite, *Gastrioceras excelsum* Meek, was recently collected by Mr. Ben H. Wilson, a member of the Academy. The specimen came from the Appa-

noose formation at Mystic, Iowa, and is said to have been taken from a shale just below a coal seam at a depth of fifty to sixty feet. The type of this species and one or two other examples came from the Pennsylvanian of Kansas; others are recorded from Arkansas; the specimen here reported is the first from Iowa. Illustrations.

Some Oligocene Brachiopods from the Island of Antigua, B. W. I.: A. O. THOMAS. In the Antigua limestone at Half Moon Bay, Antigua, there occurs an abundance of lepidocycline foraminifera, a number of sea-urchins, some corals, pelecypods, a few gastropods, and rarely some brachiopods belonging to the genera *Argyrotheca, Terebratulina,* and *Liothyrina.* They appear to be new species though the Liothyrinas are close to those reported by Guppy from Trinidad over fifty years ago. These small forms have added interest since very little is known about the brachiopods of the American Oligocene.

Note on a beaver tooth from the Pleistocene at Des Moines, Iowa: A. O. THOMAS. The specimen is an incomplete incisor tooth of the giant beaver, *Castoroides ohioënsis* Foster. It was found by Mr. B. A. Wickham in gravels of uncertain age while making an excavation near the west city limits. This is the third locality record from Iowa, the others being Turin and Oakland. Illustration.

Some proboscidean remains found in Henry county, Iowa: H. E. JAQUES.

The loess fossils of western Tennessee: B. SHIMEK.

PHYSICS AND ASTRONOMY

A laboratory optical pyrometer: Notes on its design and operation: WM. SCHRIEVER.

(1) *Measurements of the amplitude of vibration of the diaphragm of the Hewlett tone generator.* (2) *Determination of the minimum audible intensity of tones of high frequency:* CLARENCE E. LANE.

A low frequency acoustic wave filter: G. W. STEWART.

(1) *The effect of drawing on the crystal structure of tungsten wires.* (2) *A note on Kater's reversible pendulum:* L. P. SIEG.

The coefficient of rigidity, and Young's modulus for hexagonal crystals of selenium: L. P. SIEG and R. F. MILLER.

The absorption of light passing through deep slits, as a function of the length and depth of the slits and of the wave length of the light: L. P. SIEG and A. T. FANT.

The tactual analogy of stroboscopy: L. E. DODD.

Scattering of X-rays in carbon: C. W. HEWLETT.

A new loud speaking telephone receiver: C. W. HEWLETT.

Hall effect in thin films: J. C. STEINBERG.

The Alpha lines in the "K" series tungsten spectrum: CHARLES CROFUTT.

A note on Nova Cygni, No. 3: D. W. MOREHOUSE.

Review of solar observations at Alta, Iowa, during the past thirteen years, 1908–1920: DAVID E. HADDEN.

ZOOLOGY

A study of the nesting habits of the Baltimore oriole: H. E. JAQUES and KATHERINE GILMORE.

Nactarina in the United States: FRANK C. PELLETT.

Corn oil cake meal for growing and fattening pigs: JOHN M. EVVARD.

Notes on the mammals observed in Marshall county, Iowa: IRA N. GABRIELSON.

Bird banding and incidental studies: DAYTON STONER.

Burrows and burrowing habits of the common mole: A. V. ARLETON.

Some observations on certain Cladocera: FRANK A. STROMSTEN.

Alcohols as factors altering fatigue processes in frog muscle: FRANCIS M. BALDWIN.

Analysis of certain smooth muscle responses: B. M. HARRISON and FRANCIS M. BALDWIN.

Notes on the differential viability in Gambusia: S. W. GEISER. Author presents evidence to show that in the shipment of *Gambusia affinis,* the common mosquito fish, the males have a higher death rate than the females, both in winter and summer shipments. He shows by experiments that this higher death-rate is not due to warming of the water in the shipping can, but is owing to other causes. The male death-rate in warm weather shipments is much higher than that of those sent in cold weather; in the females, there is no corresponding increase in the death-rate. He combats the evidence brought forward (1921) by Barney and Anson to show a higher death-rate among the females in shipments of Gambusia.

The distribution of the European elm scale: Albert Hartzell.

Further studies of the relative position of the maxima contractions of the amphibian muscle when subjected to the various ranges in temperature: R. L. Parker.

Cytology of the large nerve cells of the crayfish (Cambarus): L. S. Ross.

The readjustment of the peripheral lung motor mechanism after bilateral vagotomy: T. L. Patterson.

A new Trematode parasite of the Unionidæ: Harry M. Kelly.

Two insect pests on clover: H. E. Jaques.

Methods of teaching parasitology: Herbert R. Werner. (Posthumous.)

Insect parasitism with special reference to parasitic Diptera: Ivan L. Ressler. This paper is a review of the important publications which have appeared since 1602, on insect parasitism, when the exit of the Hymenopterous parasite, *Apanteles glomeratus* L., from the common cabbage butterfly was observed. Parasitism as a factor in insect control is discussed as well as other natural agencies of control. The various families of the Diptera are classified with reference to their predatory or parasitic characteristics. The biology of the Tachinidæ which is probably one of the best known of the parasitic Diptera, is discussed at length.

BOTANY

Notes on the genus Catherinea in Iowa.—I: Lucy M. Cavanaugh. A discussion of variation in leaf-characters in this genus as represented in Iowa.

The use of common names for plants: B. Shimek. A presentation of some objections to the use of "common names" for plants.

A prairie grove in eastern Illinois: B. Shimek. A discussion of an isolated grove on the prairies at Royal, Illinois, and the evidence which it offers towards the solution of the problem of the treelessness of the prairies.

Some noteworthy fungi from South Carolina: Guy West Wilson.

Dr. Rudolph Gmelin and his collection of Minnesota, Wisconsin and Iowa plants: R. I. Cratty. Dr. Gmelin lived for many years practicing his profession as a physician and surgeon at Elkader, Iowa, and other points, and a brief biographical sketch and a list of plants collected by him is presented.

Two additions to our list of Cruciferae: R. I. Cratty. A brief paper on *Brassica juncea* (L.) Cosson, the Indian mustard, and *Lepidium perfoliatum* L., a recent emigrant from the old world.

A brief survey of economic botany: L. H. Pammel.

Studies in the germination of some woody plants: L. H. Pammel and Charlotte M. King.

Some wound responses of foliage leaves: Robert B. Wylie.

Notes on phycomycetes: I. E. Melhus.

A list of some of the phycomycetes in Iowa: J. M. Raeder.

A key to the plant families of central Iowa: Winifred Ellsworth and Henry S. Conard.

Fossil plants and classification: Henry S. Conard.

A study of the vegetation of Austin Bluffs, near Colorado Springs, Colorado: T. J. Fitzpatrick. An intensive study was made of this area during the summer of 1920. As the location occupies an intermediate position between that of the plains on the one side and the mountains on the other its flora is an interesting one.

CHILD WELFARE

Research in the field of mental and physical development of children: B. T. Baldwin and Lorle I. Stecher.

IOWA SECTION, MATHEMATICAL ASSOCIATION OF AMERICA

Correlation between mental tests and grades in mathematics of freshman engineering students: Maria M. Roberts.

Playing with the sine and projection formulas: W. J. Rusk.

Certain summation formulas: John F. Reilly.

Some properties of the function $w = \tanh z$: F. M. Weida.

Derived solutions of differential equations: M. E. Graber.

The surface $z = \log_y x$: C. W. Emmons.

Circles mutually tangent and tangent to concentric circles at specific points: C. W. Wester.

A study of certain reports of the "National Committee on Mathematical Requirements": Committee Report. J. V. McKelvey, *Chairman.*

James H. Lees,
Secretary